Springdale Dye Traces 2016

Olmsted County, MN

Calvin Alexander dumping dye into the Campion Sinkhole
Photo by Martin R. Larsen

Calvin Alexander dumping dye into the Allen Sinkhole
Photo by Martin R. Larsen

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Introduction

A collaborative partnership between the Minnesota Department of Natural Resources, University of Minnesota and the Olmsted County Feedlot Technician began in 2014 to delineate springsheds in Olmsted County. The partnership has been useful in facilitating field work, sharing expertise and educating landowners about groundwater sensitivity. Protection of groundwater quality in a karst geologic region can be enhanced by detailed knowledge of the local hydrogeologic properties such as recharge areas, discharge points, connections between inputs and emergences and point-to-point travel times. Only in the rare situation where a cave can be entered and surveyed, can the actual geometry and location of bedrock conduits be accurately determined. The delineation of springsheds helps to define water contribution areas to springs, which, in turn, aids in identifying pollution source points and potential environmental impact.

Sensitive areas were identified in Olmsted where previous dye traces have not been conducted and where karst aquifers are highly vulnerable to contamination. The dye traces were initiated on March 7, 2016 in Eyota and Marion Townships in the South Branch Bear Creek watershed.

Participating Agencies

The dye traces were conducted by Martin Larsen of the Olmsted County Soil and Water Conservation District, Jeff Green of the Minnesota Department of Natural Resources (DNR) Ecological and Water Resources Division, and E. Calvin Alexander, Jr of the University of Minnesota Earth Sciences Department. The DNR supplied charcoal detectors and logistical support. Olmsted SWCD gained permission to access the injection/sampling locations and provided staff time and logistical support. Dye and analysis of the charcoal detectors was done at the University of Minnesota by Scott Alexander and Sophie Kasahara. Betty Wheeler prepared appendix A.

We thank the local landowners for their participation in this effort and for permission to visit the springs and sinkholes on their property. These traces would not have been possible without their participation and permission.

Dye Trace Methods

Dye tracing uses the injection of fluorescent dyes into karst surface features such as sinkholes to track groundwater flow directions and travel times. Dye type and mass were chosen based on previous dye use, spring geometry and potential travel distances.

Dyes were flushed into the conduit system by utilizing snow meltwater running into the sinkholes. The dyes flowed through the underground conduit system until they re-emerged and were adsorbed onto the charcoal in the bugs.

On March 7, 2016 at 12:55, 532.9 grams of Eosine (33 weight % solution) was dumped into the Campion Sinkhole (MN55:D00833) located at 555890 E / 4866592 N. The Campion Sinkhole is deep with a swallow hole which is buried by miscellaneous garbage and scrap iron. The specific injection location was chosen where melt water was seen flowing (trickling) further into the sinkhole. The dye was poured below the meltwater, then fully covered with additional snow. See cover photo.

At 13:37, 426.17 grams of Rhodamine WT (17.7 weight % solution) was dumped into the Ron Allen Sinkhole (MN55:D00839) located at 555401 E / 4866780 N. The Allen Sinkhole is approximately three

feet deep with a visible two foot swallow hole at the bottom. Unlike the Campion sinkhole, trickling melt water was not located or visible. At least two injection sites in the sinkhole were chosen and the snow was shoveled out. The dye was dumped at the bottom of the injection sites and re-covered with snow. See cover photo.

Dye Trace Setting and Study Area

Figure 1 shows the location of the Springdale Dye Traces study area in relation to the state of Minnesota and Olmsted County.

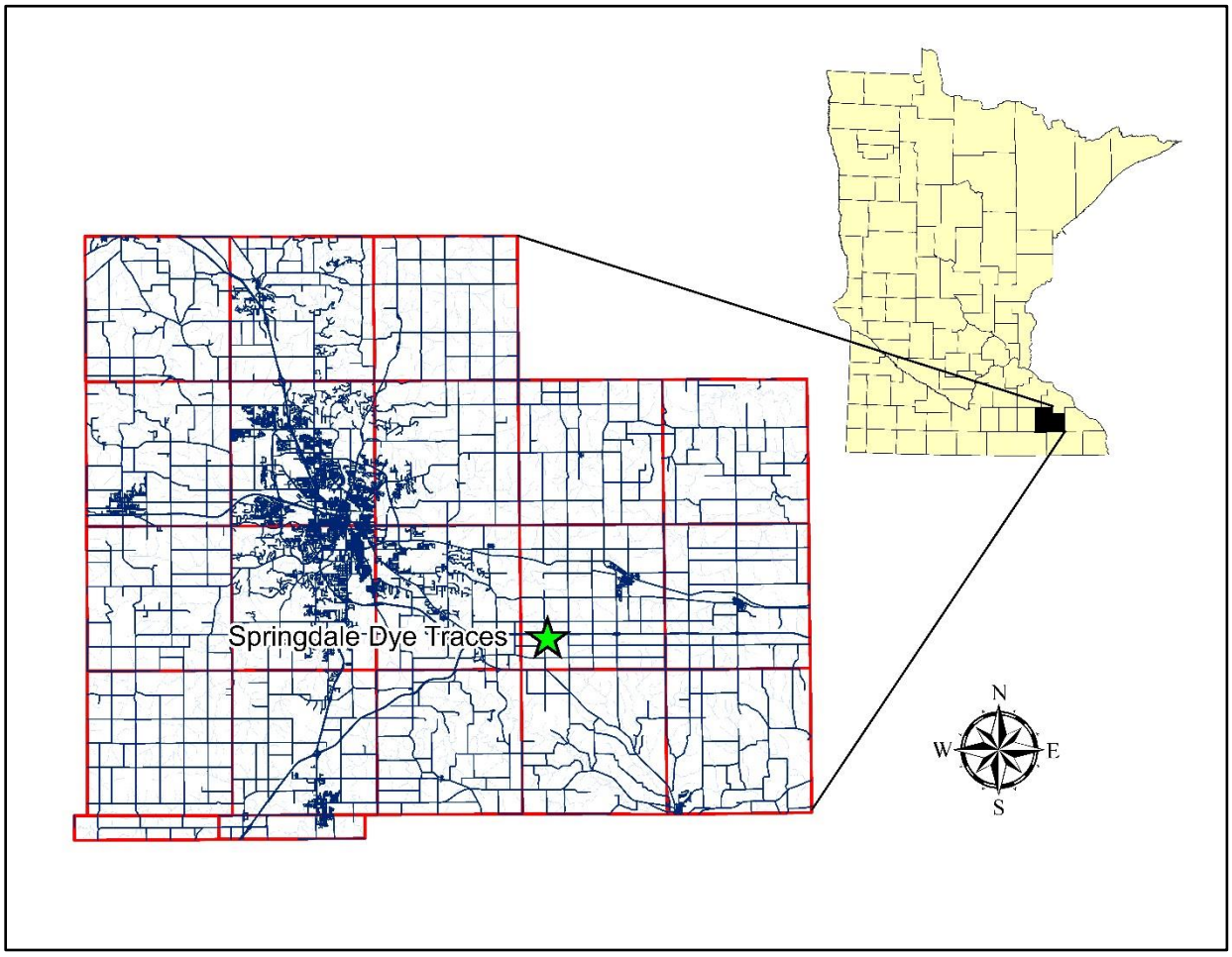


Figure 1. Dye Traces location

Figure 2 shows the Springdale Dye Traces study area. The study area is on a relatively flat interfluve between the Bear Creek drainage to the north and the North Branch of the Root River to the south. The Study area is primarily in row crop agriculture and is bisected by the I90 Interstate Highway. The two selected dye injection points in Eyota Township are at locations where the Prosser Formation of the Galena Group is the first bedrock. All of the monitoring points are connected to springs that emanate from the Lower Prosser and upper Cummingsville Formations above the Decorah Shale Formation (Figure 3). Monitoring points were selected to completely surround the dye input points (Figure 2). The locations, Karst Feature Database ID numbers and the field labels of the injection points and springs monitored in these dye traces are listed in Table 1.

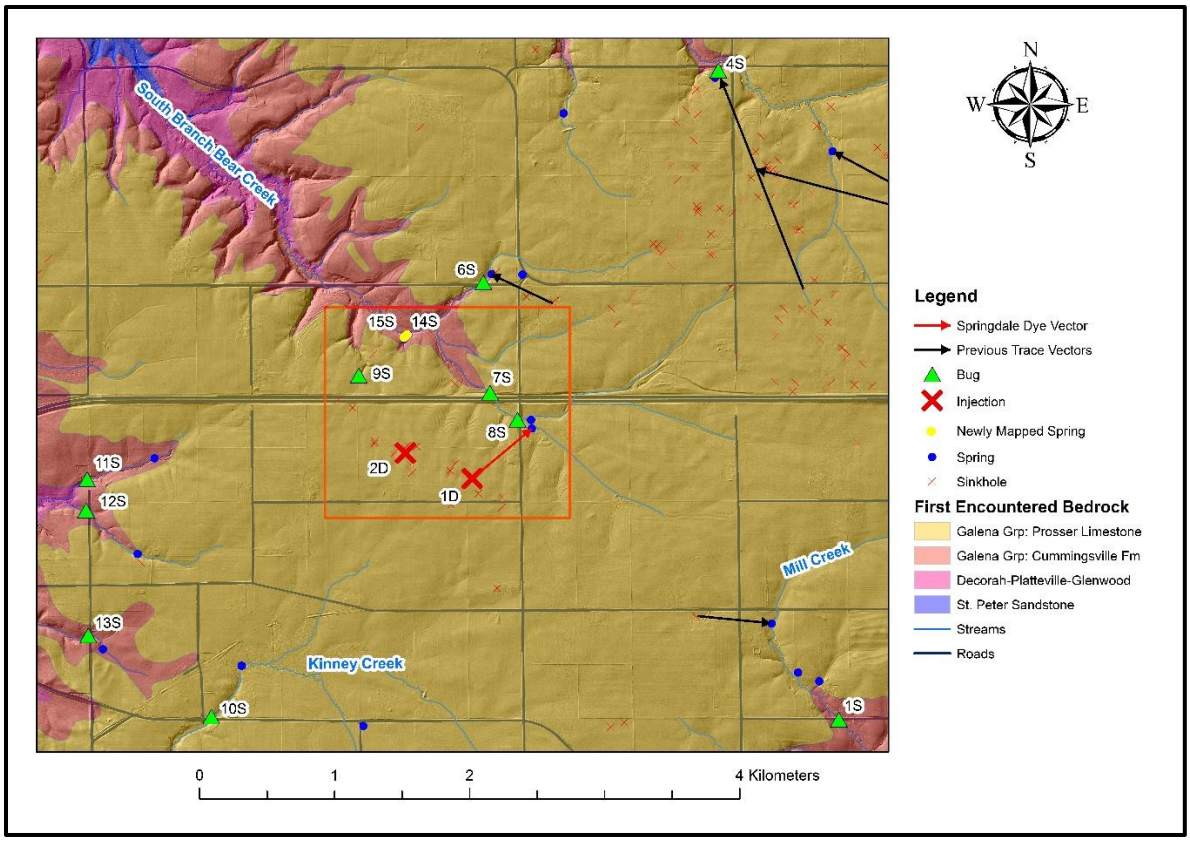


Figure 2. 2016 Springdale Dye Traces Study Area. Dye input points, monitoring points, black dye vectors from previous traces in the Study Area (Johnson, et al., 2015; Larsen et al. 2016.) The rectangle outlined in red is Figure 4.

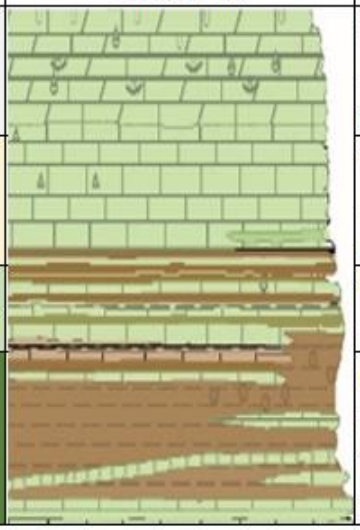
GP	FORMATION	GRAPHIC	DESCRIPTION	
Galena	Stewartville		Fine Grained dolomite and dolomitic limestone; weathered surfaces appear pitted.	Highly karstified.
	Prosser		Very Fined Grained, thin bedded limestone that becomes dolomitic near the top.	
	Cummingsville		Very fine grained limstone and interbedded calcareous shale.	
	Decorah		Green, calcareous shale with thin interbeds of limestone and is commonly very fossiliferous. Widely considered an aquitard.	

Figure 3. 2016 Springdale Dye Trace geologic stratigraphy (adapted from Alexander, et al. 1988)

Dye Trace Features					
NAME	**KFDB #**	**Classification**	**Label**	**UTM E**	**UTM N**
Dye Input Points					
Campion Sinkhole	MN55:D00833	Sinkhole Injection Point	1D	555893	4866593
Allen Sinkhole	MN55:D00839	Sinkhole Injection Point	2D	555400	4866780
Dye Monitoring Points					
Pagel / Jacobson	MN55:X00024	Spring Run Sample Point	1S	558605	4864810
Bear Spring	MN55:A00406	Spring Sample Point	4S	557705	4869620
Jones Spring	MN55:X00023	Spring Run Sample Point	6S	555976	4868040
I-90 Spring	MN55:A00405	Spring Sample Point	7S	556023	4867224
Springdale Spring	MN55:X00009	Spring Run Sample Point	8S	556224	4867028
Bird Man Spring	MN55:A00590	Spring Sample Point	9S	555044	4867651
Highway 52	MN55:X00011	Spring Run Sample Point	10S	553954	4864837
70th Ave North	MN55:X00030	Spring Run Sample Point	11S	553044	4866578
70th Ave Middle	MN55:X00031	Spring Run Sample Point	12S	553023	4866351
70th Ave South	MN55:X00032	Spring Run Sample Point	13S	553039	4865430
Higgins Seep	MN55:A00593	Spring Sample Point	14S	555411	4867652
Higgins Spring	MN55:A00592	Spring Sample Point	15S	555389	4867632

Table 1. 2016 Springdale Traces dye input and monitoring locations.

Sampling Schedule

Prior to injection, charcoal packet detectors (bugs) were placed in the identified springs, or in spring runs downstream of the identified springs, to determine background conditions. Passive dye detectors were used for sample collection. All samples were analyzed at the University of Minnesota, Department of Earth Sciences laboratory using a scanning spectrofluorophotometer.

Background charcoal detectors were distributed for the first time on 18 February 2016. The background bugs were changed on 28 February 2016. Bugs were changed a third time the day before the dye injection. The bugs were replaced four days following the injection. Bugs were then replaced seven days later and then on a bi-weekly basis. By consensus agreement among participants, sampling was terminated on 13 May 2016.

Results

The results of the analyses of the charcoal detectors are summarized in Appendix A and shown in Map view in Figure 4.

Eosine was traced from the Campion Sinkhole (MN55:D00833) to the Springdale Spring Run (MN55:X00009 associated with MN55:A00443) as shown in Figure 4 by the red vector. Eosine appeared to move through the karst conduit system quickly and was no longer detected after 18 March 2016. A runoff event took place on 15 March 2016 where one inch of rain fell in the area. Eosine dye was not detected at other monitored locations.

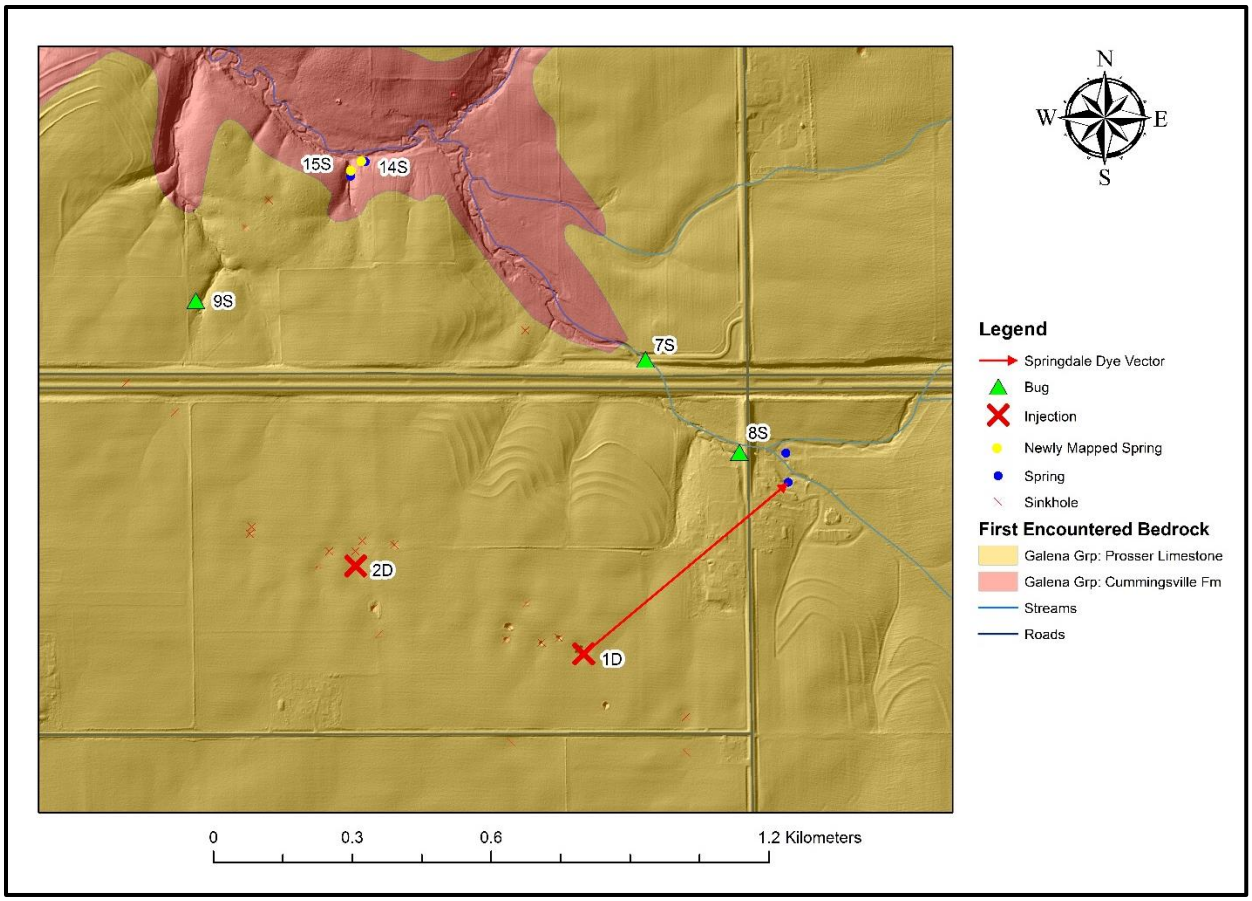


Figure 4. 2016 Springdale Dye Traces Study Area. Dye input points, monitoring points, Red dye vector is the connection made during the Springdale Dye Traces.

Rhodamine WT injected into the Allen Sinkhole (MN55:D00839) was not detected in the monitored spring runs or springs. A positive connection was not made from this dye injection.

Uranine was detected in the Jones spring in four bugs (labeled as 6S in Figure 2). The Uranine detected at Jones was still in the karst conduit system from a fall dye trace completed in 2015. Uranine was no longer detected after March 18, 2016.

Two new springs were identified through this study, Higgins Seep (MN55:A00593) and Higgins Spring (MN55:A00592) and are shown on Figure 4 (labeled as 14S and 15S). The positive dye trace to Springdale was the first connection to be made. A follow up trace may be planned to determine if a positive trace can be made from the Allen Sinkhole (MN55:D000839).

The results of these traces and previous traces are shown in Figure 2. The data from these traces was presented as a poster at the fall 2016 Geological Society of America Meeting (Larsen et al., 2016).

References

Alexander, E. Calvin, Jr. and Maki, Geri L. (1988) Sinkholes and Sinkhole Probability. Plate 7 in *Geologic Atlas of Olmsted County, Minnesota*, County Atlas Series, Atlas C-3, Minn. Dept. of Natural Resources, St. Paul.

Johnson, S. B., Green, J. A, Larsen, M. R., Kasahara, B. J., and Alexander, E. C., Jr. (2014) Wiskow Dye Traces 2014 Olmsted County, Minnesota, 15 p. + Appendix, Report available at http://hdl.handle.net/11299/185060

Larsen, Martin R., Jeffrey A. Green, Betty J. Wheeler, Sophie M. Kasahara and E. Calvin Alexander Jr. (2016) Groundwater tracing in Orion, Marion and Eyota Townships of Olmsted County, Minnesota. (Poster, Paper 252-3), Geol. Soc. Amer. Abstracts with Programs. Vol. 48, No. 7.

Olsen, Bruce M. (1988) Bedrock Geology. Plate 2 in *Geologic Atlas of Olmsted County, Minnesota*, County Atlas Series, Atlas C-3, Minn. Dept. of Natural Resources, St. Paul.

Appendix A: Springdale 2016 Traces 7 March 2016 (2 Traces)

Carbon (Bug) Analysis Results

Trace Inputs Date/Time: 7 Mar 2016

Trace Input Location 1: Ross Campion Sinkhole

Campion Sinkhole (MN55:D00833) (555,890 E / 4,866,592 N ± 1.9 m; NAD 83, Zone 15): poured 532.90 grams Eosin (33 weight % solution) (Chromatint Red) at 12:55. The trace was done in a sinkhole with melting snow. Dye was poured at 12:55 on 7 Mar 2016 on the east side of the sinkhole where runoff was dripping, with a small runnel. The pour site was backfilled and covered with snow to add water and provide sun shade.

Trace Input Location 2: Ron Allen Sinkhole

Allen Sinkhole (MN55:D00839) (555,401 E / 4,866,780 N ± 2.0 m; NAD 83, Zone 15): poured 426.17 grams Rhodamine WT (17.7 weight % solution) (Chromatint) at 13:37. The trace was done in a sinkhole with snow. Dye was poured at 13:37 on 7 Mar 2016. The dye was initially divided (approximately in half), and each was poured onto the snow in the bottom of one of two 2-foot deep holes. The pour site was backfilled and covered with snow to add water and provide sun shade.

Field Personnel at Inputs and/or Sampling: Martin Larsen, Dr. E. Calvin Alexander, Jr., Jeff Green.

Lab Personnel: Sophie M. Kasahara, Betty J. Wheeler, Dr. E. Calvin Alexander, Jr.

	Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		Background 07 Dec 15 to 21 Jan 16	Background 18 Feb 16 or 19 Feb 16 to 28 Feb 16	Background 28 Feb 16 to 7 Mar 16	Dye Input 7 Mar 2016	7 Mar 16 to 11 Mar 16	11 Mar 16 to 18 Mar 16	18 Mar 16 to 30 Mar 16	30 Mar 16 to 13 May 16
				Easting	Northing								
1S	Pagel / Jacobson Bug Set	MN55:X00024 (associated with: MN55:A0000444)	spring run	558,605	4,864,810		not detected (in: 19-Feb-16)	not detected		not detected	not detected	not detected	not detected
4S	Bear Spring (aka, Bear Creek Headwaters Perennial Spring)	MN55:A00406	spring	557,714	4,869,606	not detected	not detected (in: 18-Feb-16)	not detected		not detected	not detected	not detected	not detected
6S	Jones Spring Run Bug	MN55:X00023 (associated with: MN55:A0000008)	spring run	555,976	4,868,040	Strong Uran Positive	not detected (in: 18-Feb-16)	Uran Positive		Strong Uran Positive	Strong Uran Positive	not detected	not detected
7S	I-90 Spring Run	MN55:X00022 (associated with: MN55:A0000405)	spring run	556,001	4,867,240		not detected (in: 19-Feb-16)	not detected		not detected	not detected	not detected	not detected
8S	Springdale Spring Run	MN55:X00009 (associated with: MN55:A0000443)	spring run	556,229	4,867,025	not detected	not detected (in: 18-Feb-16)	not detected		Strong Eosin Positive (diluted 2-fold)	Eosin Positive (small but significant)	not detected	not detected

Appendix A: Springdale 2016 Traces 7 March 2016

(continued)

	Field Name	KFD #	Site Type	UTMs NAD 83, Zone 15		Background 07 Dec 15 to 21 Jan 16	Background 18 Feb 16 or 19 Feb 16 to 28 Feb 16	Background 28 Feb 16 to 7 Mar 16	Dye Input 7 Mar 2016	7 Mar 16 to 11 Mar 16	11 Mar 16 to 18 Mar 16	18 Mar 16 to 30 Mar 16	30 Mar 16 to 13 May 16
				Easting	Northing								
9S	Bird Man Spring	MN55:A00590	spring	555,055	4,867,352		not detected (in: 18-Feb-16)	not detected		not detected	not detected	not detected	not detected
10S	Kinney Creek @ US 52 (aka, Predmore) (aka, Highway 52)	MN55:X00011 (associated with: MN55:A0000492)	spring run	553,973	4,864,825		not detected (in: 18-Feb-16)	not detected		not detected	not detected		not detected
11S	70th Ave. North Spring Run	MN55:X00030 (associated with: MN55:A0000495)	spring run	553,046	4,866,585		not detected (in: 19-Feb-16)	not detected		not detected	not detected	not detected	
12S	70th Ave. Middle Spring Run	MN55:X00031 (associated with: MN55:A0000494)	spring run	553,038	4,866,355		not detected (in: 19-Feb-16)	not detected		not detected	not detected	not detected	not detected
13S	70th Ave. South Spring Run	MN55:X00032 (associated with: MN55:A0000493)	spring run	553,054	4,865,431		not detected (in: 18-Feb-16)	not detected		not detected	not detected	not detected	not detected
14S	Higgins Seep	MN55:A00593	spring	555,411	4,867,652					not detected	not detected	not detected	not detected
15S	Higgins Spring	MN55:A00592	spring	555,389	4,867,632					not detected	not detected	not detected	not detected

indicates no bug or sample was received by the lab

Eos indicates Eosin dye was detected

Uran indicates Uranine (fluorescein) dye was detected (from a previous dye trace)